Reflection Spectra of $Al_{1-x}Ga_xN$

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Reflection spectra of AlN , GaN and their mixed crystal ($Al_{1-x}Ga_xN$) from visible to vacuum ultra violet have been measured to investigate optical properties of $Al_{1-x}Ga_xN$ and their *x* dependence. The dependence of the spectral structure around the fundamental optical gap on both composition and temperature are also investigated.

The reflection experiments were carried out at 3 m McPherson type normal incidence monochromator beamline (BL7B) of UVSOR (synchrotron radiation light source), Institute for Molecular Science from 3 eV to 30 eV [1]. GaN (x = 1) thin films were fabricate on α–Al_2O_3 substrate at Nichia Chemical Ltd. The other films (x = 0, 0.1, 0.3, 0.45, 0.6, 0.69, 0.75, 0.95) were grown on SiC substrates at RIKEN. The concentration *x* was determined by the lattice constant of each sample. Incidence angle of the reflection measurement was 15 degree. To avoid the influence of the higher order lights and the scattered lights, several kinds of the combinations of the detectors with higher energy cut filters. The temperature dependence measurements have been carried out by using flow-type liquid helium cryostat from 20 K to 300 K under the pressure of 10^{-9} Torr.

Figure 1 shows the reflection spectra of AlN (x = 0), $Al_{0.55}Ga_{0.45}N$ (x = 0.45), GaN (x=1) at 20 K. The fundamental absorption edge of each material is indicated by the arrow in Fig. 1. The spectral feature of GaN is in agreement with the other work which was measured at 300 K [2]. The interference pattern due to the multiple reflection can be seen below band edge in each spectrum. The peak at around 23 eV is due to the transition from Ga 3d core level, because this peak disappears at x = 0. There are two regions in band to band transition region. Region I which is the region below ~ 12 eV shows the clear *x* dependence. The sharp peak

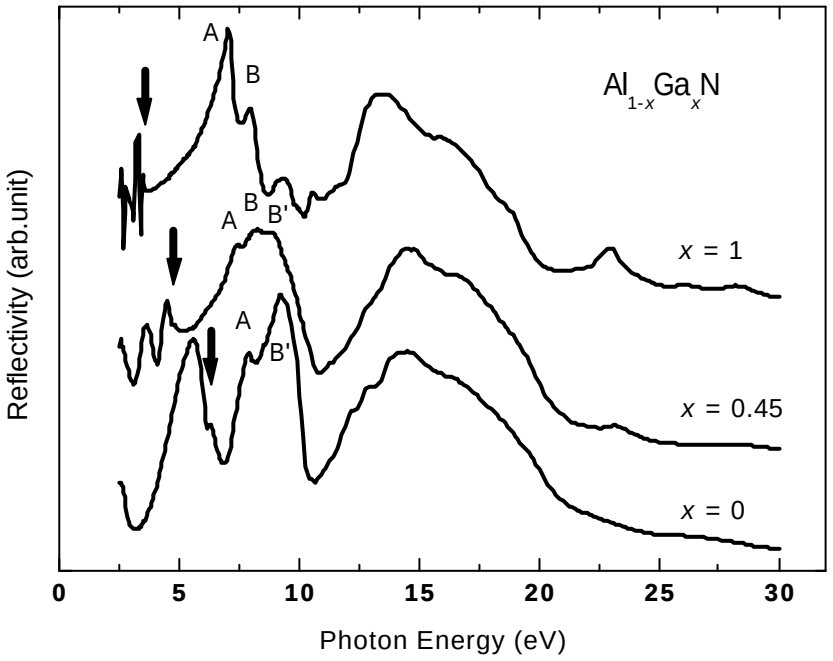

Fig.1. Reflection spectra of AlN (x = 0), $Al_{0.55}Ga_{0.45}N$ (x = 0.45), GaN (x=1) at 20 K. The fundamental gap of each materials is indicated by the arrow

A at x = 1 in Fig.1 decreases with decreasing x, and the other peak B at x = 0 decreases with increasing x. Therefore, the spectrum at middle molar fraction fraction (x = 0.45) looks like no remarkable peak in region I. On the other hand, region II (above ~ 12 eV) represents similar spectral feature. It may represent that the deep transitions mainly consist of nitrogen states.

Figure 2 shows the reflection spectra around the fundamental absorption edge of $Al_{0.4}Ga_{0.6}N$ as the function of temperature. Wave-like feature at the lower energy side is the interference pattern due to the multiple reflection as mentioned above. The end point of the interference pattern which represent the optical band gap is almost constant below 100 K. However, it becomes decreasing with increasing temperature above 100 K. The temperature dependence of the optical band gap which is found in Fig. 2 is typical result for all $Al_{1-x}Ga_xN$, and is not available to explain by the Varshni equation [3].

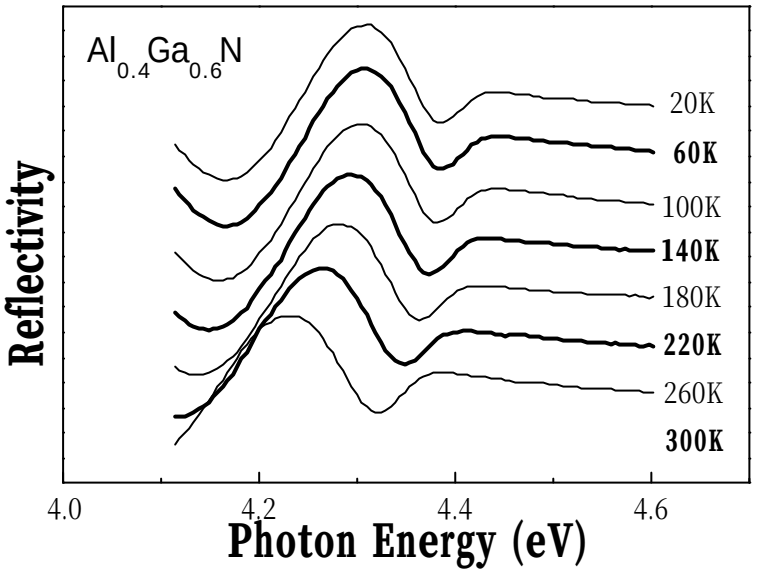

Fig.2. Dependence of the reflectivity spectra around the fundamental absorption edge of $Al_{0.4}Ga_{0.6}N$ on temperature.

References

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